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THE TACONIC QUESTION RESTATED.

BY T. STERRY HUNT.

(Concluded from page 250.)

§ 29. It must be further noted that the term Taconic, unless qualified and limited as Upper Taconic, includes, besides this Cambrian, another and a not less important series of rocks which cannot be brought into parallelism with either Cambrian or Silurian, and is separated from the Upper Taconic by great lithological differences, as well as by stratigraphical relations and by geographical distribution. We have shown that Eaton long ago pointed out the well-marked stratigraphical discordance between the base of the First Graywacke and the Transition Argillite; and it is also to be observed that the Lower Taconic, which consists of this Argillite (called by Emmons the Magnesian Slate, but including a band of roofing-slate), of the Primitive Lime-rock or Stockbridge limestone, and of the Primitive Quartz-rock or Granular Quartzite, is in many places wanting at the base of the First Graywacke. Indeed, it is not recognized by its distinctive characters along the western border of the Atlantic belt anywhere within the province of Quebec or in northern Vermont; where the Upper Taconic rests upon more ancient crystalline hornblendic and chloritic rocks very unlike the Magnesian slate of Emmons, and where, moreover, neither the Primitive Lime-rock nor the Primitive Quartz-rock are known.

That the green sandstones and conglomerates which make the basal beds of the Upper Taconic contain the ruins of these older crystalline rocks, was already noticed by Emmons, and is seen at many points, notably at Pistolet Bay, in Newfoundland, where a great body of these rocks, which were referred to the Sillery division of the Quebec group, rests directly upon a series of hornblendic and chloritic rocks with serpentines. This immediate superposition of the Sillery sandstones to these crystalline schists was explained in Logan's hypothesis by the double assumption that the green sandstone is the uppermost member of the so-called Quebec group and has escaped an imagined alteration, and that the immediately underlying crystalline rocks belong to the Lauzon or middle member of the same group, which has been altered. When, subsequently, Logan traced the great Graywacke belt of Eaton southwestward into Vermont, and along the western base of the Taconic Hills to the Highlands of the Hudson, recognizing its identity with his Quebec group, and finding it, in its southward extension, to rest in many parts on the crystalline limestones of the Lower Taconic (the Primitive Lime-rock), he declared these to be the altered representatives of the Levis or Sparry Lime-rock, made by him the lowest division of the same Quebec group; the Lauzon, according to his hypothesis, while nearly four thousand feet in the vicinity of the city of Quebec, being elsewhere reduced to a very thin layer, or entirely wanting.

§ 30. That the great crystalline series which forms the Lower Taconic of Emmons lies, as maintained by Eaton, beneath the horizon of the First Graywacke, from which it is separated by a stratigraphical discordance, is thus confirmed by Logan, as well as by J. B. Perry, who, in 1867, described the Lower Taconic as consisting of quartzites, marbles, and talcose schists; and, later, by Marcou, who also notes the want of conformity between the Lower and Upper Taconic. That the horizon of the Lower Taconic is in fact below that of the First Graywacke is disputed by no one who has ever studied the region in question, and the only ground on which it can be assigned to a higher horizon is by maintaining the old error of Mather, who conjectured this First Graywacke or Upper Taconic to be newer instead of older than the Trenton limestone,—a mistake now recognized by all who have investigated this Graywacke belt.

We have elsewhere pointed out the grounds on which those who followed the erroneous view of Mather as to the horizon of the First Graywacke regarded the Lower Taconic quartzites and limestones as Trenton or post-Trenton in age. C. B. Adams and W. B. Rogers regarded the Red Sand-rock and its associated limestones near Burlington, Vermont, which are included in the First Graywacke, as of Medina (or Medina and Clinton) age. Following this, Adams maintained, in 1846, that the quartzites and crystalline limestones of the Lower Taconic were but the altered equivalents of this First Graywacke, and Rogers proclaimed, in 1851, that these crystalline limestones are "probably Upper Silurian or Devonian," while Edward Hitchcock, in 1861, conceived that they "may be as recent as the Carboniferous rocks."

The rocks of the same series have elsewhere been assigned to a still higher horizon. The schistose beds, though principally at the summit, are more or less interstratified with the underlying limestones and quartzites of the Lower Taconic, and in many places include besides limonite both magnetite and hematite. Important beds of these latter ores along both borders of the triassic series in Pennsylvania, embracing those of the Warwick and Jones Mines, of Reading, Boyerstown, Dillsburg, and Cornwall, were, by H. D. Rogers, in 1839, referred to the "middle secondary red sandstone" or trias, adjoining them; the peculiar characters of these crystalline schists being supposed to be due to "the metamorphism of the strata." In 1858, however, Rogers correctly referred them to the horizon of what he called the Primal Slates. Lesley, in 1859, while apparently accepting this latter view, refers with approval to those who regard these ores "as of middle secondary and not of primary age;" in accordance with which opinion the ores of Dillsburg are, by Frazer, in 1876, in his Report of the Second Geological Survey of Pennsylvania, described as mesozoic, and by McCreath, in his report for 1881, are also referred to the same horizon.

§ 31. The ground upon which J. D. Dana still defends the original position of Mather as to the horizon of the Lower Taconic crystalline limestones, while at the same time admitting the now unquestioned pre-Trenton and Cambrian age of the Graywacke series, is by supposing that the apparent succession of eastward-dipping strata in certain sections in this region represents their order of deposition, and, consequently, that the crystalline limestones are not below the Graywacke, as taught by Mather, but above it, and are apparently the altered representative of the Sparry Lime-rock. This, notwithstanding the caution of Emmons, he confounds with the Stockbridge or crystalline limestone of the Lower Taconic, and, therefore, from the organic remains, apparently of Ordovician age, found in the Sparry Lime-rock at the summit of the Upper Taconic, assigns the same age to the Lower Taconic limestone.

§ 32. In some parts of the great valley of Pennsylvania the Cambrian Graywacke or Upper Taconic had been removed from the Lower Taconic before the Ordovician age, and now appears only in isolated areas. In like manner, the Ordovician limestones are represented only by small portions of fossiliferous strata resting upon the Lower Taconic, and probably also upon the Graywacke itself. Here also the gray Oneida-Medina sandstone is found in discordant superposition upon the Lower Taconic.

In regions outside of the great valley—to which the First Graywacke was apparently confined—are found many considerable areas of the Lower Taconic rocks, conspicuous among which are those early noticed in the Carolinas and in Georgia. Among these is a long range described and mapped by Maclure in 1817 as a "Transition belt." This is connected at its northern end with the same rocks in the great valley of Pennsylvania, and extends from the Delaware to the Yadkin River, beyond which, after a little interruption, it appears on the Catawba, and forms the King's Mountain belt in North and South Carolina; where these Lower Taconic rocks were described at length by the late Oscar Lieber as the Itacolumitic series. Without now referring to the other areas of these rocks in the Southern States, and to those which in New Jersey, Rhode Island, and Maine are found to the eastward of the great Appalachian valley, we may note the remarkable display of the same rocks at the mouth of the St. John River, in New Brunswick, and their reappearance in the Cobequid Hills, in Londonderry, Nova Scotia. To the westward, they are found on a considerable area in Hastings County, near the northern shore of Lake Ontario, where they were first described by the geological survey of Canada as the Hastings series.

§ 33. These rocks are largely developed around Lake Superior, where they were first recognized in northern Michigan by Houghton, and were described by Emmons in 1844, and again in 1855, as Taconic. They constitute the lower division of the Upper Copper-bearing series of Logan, and as seen on the north shore of the lake by the present writer were described as the Animikie series. These same rocks in northern Michigan have been, by Murray, Credner, and others, confounded with the Huronian, but the rocks of the Menominee district, including great deposits of iron ores and marbles, were, by Irving, in 1883, regarded as identical with the Animikie series, which the present writer, in 1884, referred to the Lower Taconic. These same rocks in northern Michigan were, in 1880, described by Rominger as part of a great system divided in ascending order into a Quartzite group (including a Marble series), an Iron-ore group, and an

Arenaceous Slate group, the rocks of all of which, from the descriptions, and the specimens which I have been permitted to examine, are apparently identical with the Lower Taconic as seen in Pennsylvania and elsewhere. This great system, according to Rominger, rests in some parts upon a gneissic and granitoid series (his Granitic group) and in others upon a great Dioritic group, chiefly of massive and schistose greenstones, with more or less chloritic varieties, and with closely associated serpentines, the whole group having the characters of the typical Huronian series. For many of the details respecting these rocks, elsewhere given more at length, I am indebted to the courtesy of Rominger in permitting me to consult his yet unpublished Report of the Geological Survey of Michigan for 1881–1884. It appears from a letter by Emmons to Marcou, dated December, 1860, and published by the latter in 1885, that its author had long before "claimed that the Huronian was only the Taconic system."

It is now evident that two widely distinct and stratigraphically discordant series have, around the basin of Lake Superior, been confounded under the common name of Huronian. It should, however, be said that their distinctness was noted by Logan as early as 1847, when he described the lower division (Animikie—Lower Taconic) of his Upper Copper-bearing group (its upper division being the Keweenian) as resting, on the north shore of Lake Superior, unconformably upon the ancient greenstone and chloritic group, to which the present writer, in 1855, first gave the name of Huronian, and of which fragments are there found in the basal beds of the Lower Taconic.

§ 34. Taconic (Lower Taconic) rocks, according to Emmons, are found near the Hot Springs of Arkansas, and probably occur elsewhere farther west at the base of the palæozoic. Many concordant observations show the existence of a similar series in Cuba, Trinidad, and Venezuela, and also in Brazil, where they constitute the Itacolumitic series, already compared by Oscar Lieber with that described by him in South Carolina. I have called attention to the presence in the Alps of a great series lithologically similar to the Lower Taconic, including the so-called lustrous schists or sericite schists, with granular marbles, anhydrite, quartzites, etc., as well displayed in the Mont Cenis tunnel and in the Apuan Alps. These crystalline rocks have been by many European geologists regarded as altered strata of various ages, alike mesozoic and palæozoic, but are, in the opinion of Gastaldi, of Jervis, and many others, infra-Cambrian. Rocks lithologically and stratigraphically similar occur in Spain and in Norway, as I have elsewhere pointed out.

§ 35. It now became necessary to give distinctive terms to the two great groups of strata which, although originally separated by Eaton, were at first united by Emmons in one system, afterwards divided by him into Lower and Upper Taconic. It is unfortunate that the distinctive name of " Taconic slates" given by Emmons to the Upper Taconic division,—the First Graywacke or Cambrian,—solely for the sake of distinguishing it from the lithologically similar and often contiguous slates of the Second Graywacke or Ordovician (with which they had been confounded by his colleagues under the common name of Hudson River group), should have given rise to the false notion, entertained by some, that these Cambrian slates have a better title to the name of Taconic than the underlying Magnesian slate of Emmons—with its associated roofing-slate or Transition Argillite—and the still older crystalline limestones and quartzites; all of which were, together with the " Taconic slate" group, included from the first in the Taconic system of Emmons.

That the Taconic slate group or Upper Taconic was nothing more nor less than the Cambrian of the Appalachian valley has, we think, been made clear, and that the Lower Taconic is a wholly distinct and older series is also apparent. Its granular quartzites, often flexible; its crystalline limestones and dolomites, sometimes, like the quartzites, micaceous, and occasionally including amphibole and serpentine; its schistose beds, intercalated throughout, abounding in hydrous, non-magnesian micas, and occasionally carrying chlorite, talc, serpentine, garnet, and pyroxene; the presence also in the series of cyanite, staurolite, tourmaline, rutile, diamonds, and graphite; finally, the great included beds of magnetite, of hematite, and of siderite and pyrite, both yielding limonite by epigenesis,—all serve to show the existence of a peculiar and well-defined series of crystalline rocks, which are from four thousand to ten thousand feet in thickness, and are not less distinct from the uncrystalline Cambrian Graywacke or Upper Taconic than from those older crystalline series, the Laurentian, Arvonian, Huronian, and Montalban; upon each of which, in different regions, it appears to rest in unconformable stratification. It is at the same time overlaid in New Brunswick by the Cambrian (Menevian) slates of St. John, and in very many parts of the Appalachian valley by the Cambrian Graywacke, and elsewhere in that region by the Silurian (Oneida) sandstone, and apparently by the Ordovician (Trenton) limestone, as is also the case in Ontario.

§ 36. It became evident to the writer after many years of study of these rocks, that the attempt to set aside this great factor in American stratigraphy,—already recognized by Maclure, by Eaton, and by Emmons,—and to regard it, in conformity with the fancies of the metamorphic school, alternately as altered Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and even Triassic,—was, like similar attempts in British and in European geology, a grave error.

The distinctness and unity of this great series of crystalline stratified rocks being maintained, a name for it was needed, and that of Lower Taconic given by Emmons was at hand. His Upper Taconic had by himself, and by others, been recognized as the equivalent of what had been previously designated Cambrian, a name which it was thought it should henceforth bear. To prevent confusion in nomenclature, to secure uniformity in terminology, and to connect the name of Emmons with his great achievements in American stratigraphy, the writer, in 1878, proposed for the Lower Taconic the name of Taconian, which he has since adopted.

§ 37. These rocks, although below the recognized Cambrian horizon, and, unlike them, essentially crystalline, are not destitute of the evidences of organic life. There are many reasons, both direct and indirect, apart from the existence of Eozoon, for believing that "the dawn of life," as Dawson has happily called it, began long before Taconian time. The typical *Scolithus linearis* of the basic quartzites of the Taconian,—although, as I have long since pointed out, very distinct from the somewhat similar markings (probably of two or more distinct species) found in the Cambrian (Potsdam) of the Ottawa and Mississippi basins, —is the more significant from the fact that it is found throughout the Appalachian valley, and, moreover, that something very like it, if not identical, occurs in the Taconian limestone alike in Pennsylvania and in South Carolina, as well as in the Taconian quartzites of Ontario. There also the limestones have yielded the remains of an organism, referred by Dawson to *Eozoon canadense*, filled not with a mineral silicate, as in the Laurentian serpentinic limestones, but with an earthy carbonaceous matter. To these should be added the occurrence of the remains of *Lingula*, found by Prime in the Taconian limestones of Pennsylvania, and of the remains of a keratose sponge in the argillite of this series, found by the writer in 1883 near Thomson, Minnesota. All of these facts (except the last) were insisted upon by the writer in 1876, and again in 1880, when in discussing the question whether the Taconian series is to be referred to eozoic or to palæozoic time, it was said that while to draw the line between them will be as difficult as to define that between palæozoic and mesozoic, or between mesozoic and cenozoic, "we may hope to find in the Taconic series a fauna which will help to fill the wide interval which now divides that of the eozoic rocks from the Cambrian;" adding that "we should seek in the study of stratigraphical geology not the breaks dividing groups from each other so much as the beds of passage which serve to unite all these groups in one great system."

§ 38. We have thus endeavored in the preceding pages to restate briefly the Taconic Question in some of its more important aspects. Further details, and the references to original sources, will be found in our recently published volume entitled "Mineral Physiology and Physiography," pp. 517–686. Therein appear the papers, published under the title of "The Taconic Question in Geology," in volumes i. and ii. of the "Transactions of the Royal Society of Canada in 1883 and 1884," in part rewritten and considerably augmented. In that volume will be found, on page 529, a tabular view (also published in the "Report on the Progress of Geology by the Smithsonian Institution for 1883"), wherein the stratigraphical sequence of the rocks of North America, including the Taconian series, and its relations alike to the older crystalline rocks below and to the First and Second Graywackes above, is shown to have been correctly indicated as early as 1832 by Amos Eaton, the preceptor of Ebenezer Emmons. Had the teachings of that great master in American geology been generally followed, it is not too much to say that a half-century of confusion, misconception, and controversy would have been avoided. It is the great merit of Emmons that he sought, though unsuccessfully and amidst cruel opposition and injustice, to uphold those teachings, and to the best of his ability to extend the generalizations of Eaton; in a return to which, as we have at last learned, is to be found the solution of the vexed problem of American stratigraphy.

In the tabular view above noticed the writer attempted to introduce for the first time into American geology the term Ordovician, proposed by Lapworth in 1879 for the group of strata between the proper Silurian of Murchison and the undisputed Cambrian of Sedgwick, which, though by the latter named Upper Cambrian, has been alternately called by others Lower Silurian, Siluro-Cambrian, and Cambro-Silurian, and includes the Chazy, Trenton, Utica, and Loraine subdivisions of the New York system. This name of Ordovician has since been adopted by many British and European geologists, and is now used by Mr. Charles D. Walcott, of the United States Geological Survey, whose important generalizations regarding the American Cambrian, noticed in the above volume, pages 624, 625, are given at length in his recent work in 1886, entitled "Studies of the Cambrian Faunas of North America" ("Bulletin No. 30 of the Geological Survey"), and constitute a precious contribution to our knowledge of the North American Cambrian. His table of the succession of the Cambrian, with its subdivisions, and the Ordovician, will be found on page 44 of that Bulletin.[1]

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[1] Since writing the above paper there has appeared in the *American Journal of Science* for February, 1887, an abstract by Mr. Walcott of a paper read by him in January before the Philosophical Society of Washington, in which he puts forth again, with but slight modifications, the old metamorphic hypothesis touching the Taconian rocks, as maintained by Mather, H. D. Rogers, and C. B. Adams, since resuscitated by J. D. Dana, supporting it apparently upon the assumption that certain white sandstones carrying Olenellus, found to the eastward of the Taconic Hills, are identical with the Primitive Quartz-rock of Eaton, the basal division of the Taconian. While entertaining the highest regard for Mr. Walcott's admirable work in palæontology, the writer can see in his published note no ground for revising the conclusions already set forth in the preceding pages.